

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property
Organization
International Bureau



(43) International Publication Date
29 January 2004 (29.01.2004)

PCT

(10) International Publication Number
WO 2004/010380 A3

(51) International Patent Classification⁷: **G06T 7/60**

(21) International Application Number:
PCT/GB2003/003052

(22) International Filing Date: 14 July 2003 (14.07.2003)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0216641.1 18 July 2002 (18.07.2002) GB

(71) Applicant (for all designated States except US): **THE UNIVERSITY OF NOTTINGHAM** [GB/GB]; University Park, Nottingham NG7 2RD (GB).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **SEE, Chung, Wah** [GB/GB]; 16 Mount Pleasant, Oadby, Leicester LE2 4UA

(GB). **SOMEKH, Michael, Geoffrey** [GB/GB]; 38 Renfrew Drive, Wollaton, Nottingham NG8 2FX (GB). **PITTER, Mark, Charles** [GB/GB]; 4 Rushworth Court, West Bridgford, Nottingham NG2 7LH (GB).

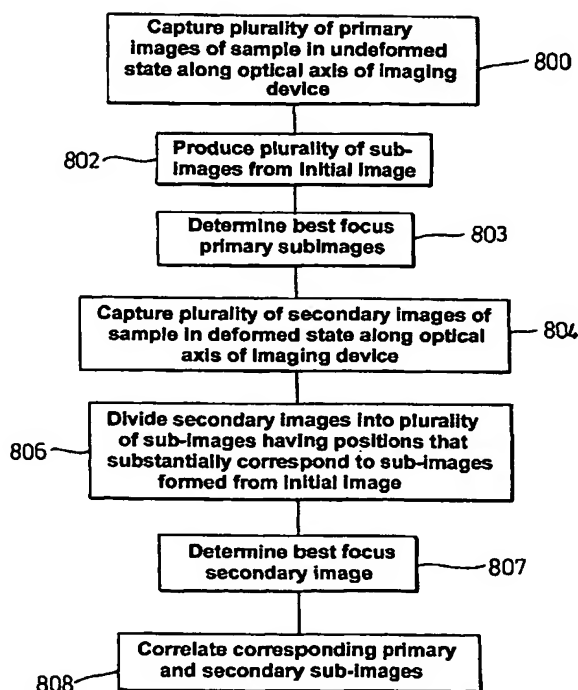
(74) Agent: **BARKER BRETTELL**; 138 Hagley Road, Edgbaston, Birmingham B16 9PW (GB).

(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO,

[Continued on next page]

(54) Title: MEASURING 3D DEFORMATIONS OF AN OBJECT BY COMPARING FOCUSING CONDITIONS FOR SHARP CAPTURING OF SAID OBJECT BEFORE AND AFTER DEFORMATION



(57) Abstract: An image analysis apparatus comprises a microscope (102) arranged to capture an image of a sample (122), a processor unit (114) arranged to process the image and a drive mechanism (108). The drive mechanism (108) varies the distance between the sample (122) and the microscope (102) along the optical axis of the microscope (102). The microscope (102) is arranged to capture a plurality of images (402a-404c) of the sample (122) at a plurality of focal planes (distances), along the optical axis. This is done for the sample in a first state and for the sample being in a second state (e.g. before and after deformation of the object). The processor unit (114) is arranged to divide each of the plurality of captured images (402a-404c) into a plurality of sub-images and select one of each of the plurality of sub-images having the best focus characteristics. Both sets of sub-images are compared to determine in-plane and out-of-plane deformations.

WO 2004/010380 A3



SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Published:

- *with international search report*
- *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

(88) Date of publication of the international search report:
29 July 2004

INTERNATIONAL SEARCH REPORT

PCT/GB 03/03052

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G06T7/60

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 G06T G01B G01C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	VOGEL D ET AL: "Microdac - a novel approach to measure in situ deformation fields of microscopic scale" MICROELECTRON. RELIAB. (UK), MICROELECTRONICS AND RELIABILITY, NO. 11/12, vol. 36, 8 October 1996 (1996-10-08) - 1996, pages 1939-1942, XP010528058 figures 1-4	12-15
Y	abstract page 1939, paragraph 3 page 1940, section "Principles of MicroDac"	1-3, 5-11, 16, 17
	--- -/-	



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

* Special categories of cited documents:

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

- *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- *&* document member of the same patent family

Date of the actual completion of the international search

1 June 2004

Date of mailing of the international search report

11/06/2004

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-5016

Authorized officer

Ellerbrock, T

INTERNATIONAL SEARCH REPORT

PCT/GB 03/03052

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	<p>ALLEGRO S ET AL: "Autofocus for automated microassembly under a microscope"</p> <p>PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON IMAGE PROCESSING (ICIP) LAUSANNE, SEPT. 16 - 19, 1996, NEW YORK, IEEE, US,</p> <p>vol. 1, 16 September 1996 (1996-09-16), pages 677-680, XP010202748</p> <p>ISBN: 0-7803-3259-8</p> <p>page 677, left-hand column, paragraph 4</p> <p>-page 678, left-hand column, last paragraph</p> <p>page 678, right-hand column, paragraph 3 - paragraph 4</p> <p>page 678, right-hand column, paragraph 6</p> <p>-page 679, left-hand column, paragraph 3</p> <p>page 680, left-hand column, paragraph 3</p> <p>----</p>	<p>1-3, 5-11,16, 17</p>
A	<p>NAYAR S K ET AL: "SHAPE FROM FOCUS"</p> <p>IEEE TRANSACTIONS ON PATTERN ANALYSIS AND MACHINE INTELLIGENCE, IEEE INC. NEW YORK, US,</p> <p>vol. 16, no. 8, 1 August 1994 (1994-08-01), pages 824-831, XP000464936</p> <p>ISSN: 0162-8828</p> <p>figures 3,8,9</p> <p>page 825, left-hand column, paragraph 3</p> <p>-page 826, left-hand column, paragraph 2</p> <p>page 827, left-hand column, paragraphs 2,4</p> <p>section "VII Automatic shape from focus system"</p> <p>page 829 -page 831</p> <p>----</p>	<p>1-17</p>
A	<p>NOGUCHI M ET AL: "Microscopic shape from focus using active illumination"</p> <p>PATTERN RECOGNITION, 1994. VOL. 1 - CONFERENCE A: COMPUTER VISION & IMAGE PROCESSING., PROCEEDINGS OF THE 12TH IAPR INTERNATIONAL CONFERENCE ON JERUSALEM, ISRAEL 9-13 OCT. 1994, LOS ALAMITOS, CA, USA, IEEE COMPUT. SOC,</p> <p>9 October 1994 (1994-10-09), pages 147-152, XP010215958</p> <p>ISBN: 0-8186-6265-4</p> <p>abstract</p> <p>----</p> <p style="text-align: center;">-/--</p>	<p>1-17</p>

INTERNATIONAL SEARCH REPORT

PCT/GB 03/03052

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>PITTER M C ET AL: "SUBPIXEL MICROSCOPIC DEFORMATION ANALYSIS USING CORRELATION AND ARTIFICIAL NEURAL NETWORKS"</p> <p>OPTICS EXPRESS, OPTICAL SOCIETY OF AMERICA, WASHINGTON, DC,, US, vol. 8, no. 6, 12 March 2001 (2001-03-12), pages 322-327, XP001166850</p> <p>ISSN: 1094-4087</p> <p>Abstract and Introduction</p> <p>-----</p>	1-17